Risk and Technology Review -

Analysis of Socio-Economic Factors for Populations Living Near Aerospace Facilities

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EPA Contract No. EP-W-12-011
Work Assignment No. 2-06

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November 4, 2014

Disclaimer

Although the analysis described in this document has been funded wholly or in part by the United States Environmental Protection Agency contract EP-W-12-011 to EC/R Incorporated, it has not been subject to the Agency's review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

Contents

1. Introduction

This document describes the approach used to evaluate the potential cancer risks associated with inhalation and air-related exposures to hazardous air pollutants (HAP) in different social, demographic, and economic groups within the population living near Aerospace facilities in the United States. This work was carried out in support of the U.S. Environmental Protection Agency's Residual Risk and Technology Review (RTR) for Aerospace source category emissions subject to Maximum Available Control Technology (MACT) requirements under 40 CFR 63 Subpart GG.

In the RTR analysis, the Human Exposure Model, Version 3 (HEM-3)[1,2,3] was used to estimate cancer risks due to the inhalation of HAP for the populations residing within 50 kilometers of Aerospace facilities in the U.S. HEM-3 estimates cancer risks at the level of census blocks using the AERMOD state-of-the-art air dispersion model developed under the direction of the American Meteorological Society (AMS) / EPA Regulatory Model Improvement Committee (AERMIC). Each census block typically includes about 50 people. Additional information on the risk analysis is available in the docket for the **National Emission Standards for the Aerospace Manufacturing and Rework Industry** rulemaking. The docket provides a report covering the inputs and specific assumptions, and addressing uncertainties.

In the current analysis, cancer risk estimates from the Aerospace HEM-3 modeling effort were linked to detailed census data in order to evaluate the distribution of risks for different demographic groups (including racial, ethnic, age, economic, educational, and linguistically isolated population categories). The following population categories were included in this analysis:

- Total population
- White
- Minority
- African American (or Black)
- Native Americans
- Other races and multiracial
- Hispanic or Latino
- Children 17 years of age and under

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1. EC/R. January 2014. Modeling for the Residual Risk and Technology Review Using the Human Exposure Model 3 – AERMOD Version. Technical Support Document prepared by EC/R Incorporated for the U.S. Environmental Protection Agency, Research Triangle Park, NC.

2. EC/R. April 2014. The HEM-3 User's Guide. Prepared by EC/R Incorporated for the U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www2.epa.gov/sites/production/files/2014-04/documents/hem3_users_guide.pdf

3. EC/R. April 2014. Multi HEM-3 and RTR Summary Programs User's Guide. Prepared by EC/R Incorporated for the U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www2.epa.gov/sites/production/files/2014-04/documents/multi_hem-3_users_guide.pdf

- Adults 18 to 64 years of age
- Adults 65 years of age and over
- Adults without a high school diploma
- Households earning under the national median income
- People living below the poverty line
- Linguistically isolated people

The HEM-3 results for a particular census block reflect the estimated level of cancer risk that would be experienced by an individual residing within the block boundaries for 70 years. In this analysis, the demographic composition of the population estimated to experience a risk greater than 1 in 1 million as a result of Aerospace emissions is compared to the demographic composition of the overall nationwide population.

The census data used in this analysis is described in Section 2. The algorithms used to compute the distributions of risk and exposure are presented in Section 3. The results of this analysis are presented in Section 4.

2. Census Data

Table 1 summarizes the census data used in the analysis, showing the source of each dataset and the level of geographic resolution. Race, ethnicity and age data are provided by the Census Bureau at the census block level. Distributions regarding household income and linguistic isolation are provided at the block group level. Distributions regarding educational status and poverty status are at the tract level. A census block contains about 50 people on average; and a block group contains about 28 blocks on average, or about 1,400 people. A census tract is larger than a block group, with each tract containing an average of 3 block groups, or about 4,300 people.

Data on race, ethnicity, and age were obtained from tables in the 2010 Census Summary File 1 (SF1).[4] SF1 gives a breakdown for the population of each census block among different racial classifications, including: White, African American or Black, American Indian or Native Alaskan, Asian, Native Hawaiian or other South Pacific Islander, other race, and two or more races. In the current analysis, the Asian, Native Hawaiian or other South Pacific Islander, and other race categories were combined into a single category. The SF1 database also indicates the number of people in each tract that are of Hispanic or Latino ethnicity. SF1 covers the 50 states, the District of Columbia, and Puerto Rico, but does not cover the Virgin Islands. Data for the Virgin Islands can be retrieved from similar tables in the Virgin Islands Summary File.[5]

4. 2010 Census Summary File 1 – United States: http://www2.census.gov/census_2010/04-Summary_File_1/ prepared by the U.S. Census Bureau, 2011. See also Technical Documentation for the 2010 Census Summary File 1.

5. Census 2010 Data for the U.S. Virgin Islands http://www2.census.gov/census_2010/11-Island_Areas_PUMS/Virgin_Islands/ prepared by the U.S. Census Bureau.

Data on education level, household income, poverty status, and linguistic isolation were obtained from tables in the Census' American Community Survey (ACS) 5-year estimates for 2005-2009.[6]

Table 1. Summary of Census Data used to Analyze Risks for Different Socio-economic Groups

Type of population category	Source of data	Level of geographic resolution
Racial categories	SF1 Table P3	Census block
Ethnic categories (Hispanic)	SF1 Tables P4 & P7	Census block
Age groups	SF1 Table P12	Census block
Level of education - adults without a high school diploma	ACS Table B15002	Tract
Households earning below the national median income	ACS Table B19001	Block group
People living below the poverty line	ACS Table B17001	Tract
Linguistically isolated people	ACS Table B16002	Block group

3. Calculation Methods

The HEM-3 models the cancer risk and noncancer hazard at a point near the geographic center of each census block and (optionally) at model user-defined receptors representing populations located within each block.[7] For the current analysis, this risk estimate was assumed to apply to all individuals residing in the block. We used block identification codes to link the HEM-3 modeling results for each block to the appropriate census statistics. This allowed us to estimate the numbers of people falling into different population categories within each block. We then analyzed the distribution of estimated inhalation risks within each population category, given the numbers of people within the category that are exposed to different risk levels. Each distribution involved a tabulation of all the census blocks modeled for the Aerospace source category. We also computed the average risk for all individuals in each population category.

Distributions of risk and average risks were computed for the raw HEM-3 model results for the Aerospace source category. For comparison, the nationwide demographic composition (i.e., population percentage in each demographic group for the country as a whole, based on the 2010 Census and 2009 ACS) is also provided in the results table.

6. 2009 Five-year American Community Survey – 2005-2009, United States: http://www2.census.gov/acs2009_5yr/summaryfile/ prepared by the U.S. Census Bureau, 2011.

7. HEM-3 generally uses the coordinates given by the census for the internal point, or "centroid" of each block. However, when the footprint of an industrial facility includes the block centroid, the model is designed to identify the highest-risk point outside of the facility's footprint.

Section 3.1 describes the calculation method used for categories where block-level data were available from the Census Bureau – racial, ethnic and age categories and the total population. Sections 3.2 through 3.5 describe calculation methods for categories where block-level data had to be estimated from tract or block group data provided by the Census Bureau – education status, household income, poverty status, and linguistic isolation.

3.1 Racial, Ethnic and Age Categories and the Total Population

Since race, ethnicity and age data are available at the census block level, the calculation of risk distributions for these categories involved a simple block-by-block accumulation of the people in each category. We began by identifying a set of bins reflecting the level of risk. The population of each block was then assigned to the appropriate risk bin based on the modeled risk level in the block. The numbers of people in each risk bin were then added together for all of the blocks modeled for the Aerospace source category:

$$H(R_{ab},s) = \sum_i^{(Ra \le Ri < Rb)} [N(s,i)] \quad (1)$$

where:

$H(R_{ab},s)$ = the population count for risk bin R_{ab}, which is between R_a and R_b for population subgroup "s"

R_i = the modeled risk level in block "í" (estimated lifetime cases of cancer per million population)

$\sum_i^{(Ra \le Ri < Rb)}$ refers to the summation over all blocks i where R_i falls in bin R_{ab}, between R_a and R_b

$N(s,i)$ = the number of people within population subcategory s, in block i

The same approach was used for the total population. The average risk for a given population category or for the total population was then calculated using the following equation:

$$A(S) = \sum_i [N(s,i) \times R_i] / \sum_i [N(s,i)] \quad (2)$$

where:

$A(s)$ = the average risk for population subgroup "s" (estimated lifetime cases of cancer per million population)

$\sum_i$ refers to the summation over all blocks "í" modeled for the emission source category

$N(s,i)$ and R_i were defined above

3.2 Level of Education

Table B15002 of the 2005-2009 ACS dataset specifies the education status for men and women age 25 and older for each census tract, based on the last grade completed. To obtain the total number of adults without a high school degree, we added together the numbers who had completed grades below a high school senior. Thus, the number of people without a high school degree equals the sum of the number of males with no schooling, the number of females with no

schooling, the numbers of males and females who have completed nursery school through 4th grade, up to the numbers of males and females who have completed some high school but not received a high school degree.

The number of adults without a high school degree as a fraction of the total population was assumed to be the same for each block in the tract. Thus, the number of adults without a high school degree in each block was computed as follows:

$$N(nhs,b/tc) = N(t,b/tc) \times N(nhs,tc) / N(t,tc) \quad (3)$$

where:

$N(nhs,b/tc)$ = number of adults without a high school diploma, in block "b" of tract "tc"
$N(t,b/tc)$ = total number of people in block "b" of tract "tc"
$N(nhs,tc)$ = number of adults without a high school diploma in tract "tc"
$N(t,tc)$ = total number of people in tract "tc"

Equation (1) was then used to generate risk distributions based on the block-level results, and Equation (2) was used to compute the average risk for adults without a high school diploma.

3.3 Household Income

Table B19001 of the 2005-2009 ACS dataset estimates the numbers of households in each block group with income for the year 2009 in various ranges, generally divided into $5,000 increments (e.g. $10,000 to $14,999, $15,000 to $19,999, etc.). The median national income for 2009 was about $50,000 per year. Therefore, in order to determine the number of households with incomes under the median income, we added the estimates for the ranges below that level. The following equation was used to estimate the fraction of households below the national median income within each census block group:

$$F(nm,bg) = [C_{<10} + C_{10\text{-}15} + \ldots + C_{35\text{-}40} + C_{40\text{-}45} + C_{45\text{-}50}] / C_T \quad (4)$$

where:

$F(nm,bg)$ = fraction of households in block group "bg" with incomes below the median national income
$C_{<10}$ = number of households with incomes under $10,000
$C_{10\text{-}15}$ = number of households with incomes from $10,000 to $14,999
$C_{35\text{-}40}$ = number of households with incomes from $35,000 to $39,999
$C_{40\text{-}45}$ = number of households with incomes from $40,000 to $44,999
$C_{45\text{-}50}$ = number of households with incomes from $45,000 to $49,999
C_T = total number of households in block group "bg"

The fraction of people living in households below the median income for each block within the block group was assumed to be the same as the fraction of households below the median income for the block group.

$$N(nm,b/bg) = F(nm,bg) \times N(t,b/bg) \quad (5)$$

where:

N(nm,b/bg) = number of people in block "b" of block group "bg" living in households below the national median income
F(nm,bg) = fraction of households in block group "bg" below the national median income
N(t,b/bg) = total number of people in block "b" of block group "bg"

Equation (1) was then used to generate risk distributions based on the block-level results, and Equation (2) was used to compute the average risk for people living in households below the national median income. It must be noted that this approach neglects any potential relationship between household size and income level within a particular block group. However, it is expected to provide a reasonable indication of the risk level of people living below the national median income, relative to the population as a whole.

3.4 Poverty Level

Table B17001 of the 2005-2009 ACS dataset estimates the total number people in each census tract living below the poverty level, as well as the numbers of people below the poverty level in different age groups. The current study did not include an analysis of poverty status by age group, only of the total population below the poverty line. The fraction of people below the poverty line was assumed to be the same for each block in the census tract. Thus, the population below the poverty line in each block was computed as follows:

$$N(p,b/tc) = N(T,b/tc) \times N(p,tc) / N(T,tc) \quad (6)$$

where:

N(p,b/tc) = number of people below the poverty line in block "b" of tract "tc"
N(T,b/tc) = total number of people in block "b" of tract "tc"
N(p,tc) = number of people below the poverty line in tract "tc"
N(T,tc) = total number of people in tract "tc"

Equation (1) was then used to generate risk distributions based on the block-level results, and Equation (2) was used to compute the average risk for people living below the poverty level.

3.5 Linguistic Isolation

Table B16002 of the 2005-2009 ACS dataset estimates the fraction of households in linguistic isolation in each block group. For this analysis, the fraction of people living in linguistic isolation for each block within the block group was assumed to be the same as the fraction of households in linguistic isolation for the block group. Thus, the population of linguistically isolated people in each block was computed as follows:

$$N(li,b/bg) = F(li,bg) \times N(t,b/bg) \quad (7)$$

where:

N(li,b/bg) =	number of people in block "b" of block group "bg" living in linguistically isolated households
F(li,bg) =	fraction of households in block group "bg" in linguistic isolation
N(t,b/bg) =	total number of people in block "b" of block group "bg"

Equation (1) was then used to generate risk distributions based on the block-level results, and Equation (2) was used to compute the average risk for people living in linguistic isolation.

4. Results

The distribution of estimated lifetime inhalation cancer risks greater than or equal to 1 in a million for different demographic groups among the population living near Aerospace facilities is shown in Table 2. For comparison purposes, Table 2 also provides the nationwide percentages of these various demographic groups. Detailed demographics data and analyses used to create Table 2 can be found in Appendix A of this document.

The results of the analysis presented in Table 2 indicate that there are approximately 180,000 people exposed to a cancer risk greater than or equal to 1-in-1 million as a result of Aerospace emissions. The specific demographic results indicate that the percentage of the population potentially impacted by Aerospace emissions is greater than its corresponding national percentage for the minority population (36% for the source category compared to 28% nationwide), the African American population (19% for the source category compared to 13% nationwide) and for the population below the poverty level (19% for the source category compared to 14% nationwide). Furthermore, other demographic groups with source category percentages greater than the corresponding national percentage include: the population over 25 without a high school diploma (17% compared to 15%); the other and multi-racial population (16% compared to 14%); the Native American population (1.5% compared to 1.1%); the population younger than 18 years old (26% compared to 24%); and the population from 18 to 64 years of age (65% compared to 63%). The other demographic categories potentially impacted by Aerospace emissions (i.e., Hispanic or Latino, ages 55 and up, and the linguistically isolated) are less than or equal to the corresponding national percentage.

Table 2. Summary of Demographic Assessment of Risk Results for the Aerospace Source Category

Emissions Basis		Demographic Group											
		Total	Minority[1]	African American	Other and Multiracial	Hispanic or Latino	Native American	Ages 0 to 17	Ages 18 to 64	Ages 65 and up	Below the Poverty Level	Over 25 Without a HS Diploma	Linguistic Isolation
Nationwide	n/a	312,861,265	28%	13%	14%	17%	1.1%	24%	63%	13%	14%	15%	6.5%
	Maximum Risk (in 1 million)	Population With Cancer Risk Greater Than or Equal to 1 in 1 million[2]											
Source Category	10	179,054	36%	19%	16%	16%	1.5%	26%	65%	9%	19%	17%	5.4%

Notes:

[1]Minority population is the total population minus the white population.

[2]Population figures are for the population residing within 50 km from the center of these facilities whose cancer risks are estimated to be greater than or equal to 1 in a million.

5. Uncertainty Discussion

Our analysis of the distribution of risks across various demographic groups is subject to the typical uncertainties associated with census data (e.g., errors in filling out and transcribing census forms), which are generally thought to be small, as well as the additional uncertainties associated with the extrapolation of census tract level data (e.g., education status and poverty status) and census block group data (e.g., income level and linguistic isolation) down to the census block level.

The uncertainties in these risk estimates include the same uncertainties in emissions data sets, in air dispersion modeling, in inhalation exposure and in dose response relationships that are associated with our source category risk estimates.

The methodology for our demographic analyses is still evolving. While this is our best attempt to provide useful information now, our thinking is continuously advancing. EPA is in the process of developing technical guidance for environmental justice analyses. We present these analyses, with their associated uncertainties, to EPA decision makers and the public as additional analyses to inform RTR decisions.

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Appendix A

Table A-1. Distribution of Inhalation Cancer Risk for Racial and Ethnic Groups

Range of lifetime individual cancer risk (chance in one million)[a]	Numbers of people in different ranges for lifetime cancer risk[b]					
	Total population	White	African American	Native American	Other and multiracial	Hispanic or Latino[c]
Modeled risk from the Aerospace source category						
0 to 1	130,431,874	86,391,970	19,655,927	1,227,282	23,156,695	25,936,844
1 to 5	169,591	109,596	32,378	2,507	25,110	25,086
5 to 10	7,950	4,839	905	118	2,088	2,779
10 to 20	1,533	848	91	25	569	836
20 to 30	0	0	0	0	0	0
Total number	130,610,948	86,507,253	19,689,301	1,229,932	23,184,462	25,965,545
Average risk (chances in one million)	0.0116	0.0115	0.014	0.0182	0.0096	0.0084

Notes:

[a]Modeled risks are for a 70-year lifetime, based on the predicted outdoor concentration and not adjusted for exposure factors.

[b]Distributions by race are based on demographic information at the census block level. Risks from aerospace emissions were modeled at the census block level.

[c]The Hispanic or Latino population is double-counted in this analysis, since different individuals within the category may classify themselves as White, African American, Native American, or other.

Table A-2. Distribution of Risk for Different Age Groups

Range of lifetime individual cancer risk (chance in one million)[a]	Numbers of people in different ranges for lifetime cancer risk[b]			
	Total population	Ages 0 thru 17	Ages 18 thru 64	Ages 65 and up
Modeled risk from the Aerospace source category				
0 to 1	130,431,874	31,554,883	82,976,844	15,900,147
1 to 5	169,591	43,196	110,472	15,923
5 to 10	7,950	2,323	5,110	517
10 to 20	1,533	609	853	71
20 to 30	0	0	0	0
Total number	130,610,948	31,601,011	83,093,279	15,916,658
Average risk (chances in one million)	0.0116	0.012	0.0117	0.0102

Notes:

[a]Modeled risks are for a 70-year lifetime, based on the predicted outdoor concentration and not adjusted for exposure factors.

[b]Distributions by age are based on modeled risk and age data at the census block level.

Table A-3. Distribution of Risk for Adults with and without a High School Diploma

Range of lifetime individual cancer risk (chance in one million)[a]	Numbers of people in different ranges for lifetime cancer risk[b]		
	Total population	Total number 25 and older	Number 25 and older without a high school diploma
Modeled risk from the Aerospace source category			
0 to 1	130,431,874	85,971,675	12,886,998
1 to 5	169,591	102,118	16,968
5 to 10	7,950	3,985	1,222
10 to 20	1,533	776	249
20 to 30	0	0	0
Total number	130,610,948	86,078,554	12,905,437
Average risk (chances in one million)	0.0116	0.0111	0.011

Notes:

[a]Modeled risks are for a 70-year lifetime, based on the predicted outdoor concentration and not adjusted for exposure factors.

[b]Distributions by education level are based on modeled risk at the census block level, and education data at the census tract level. All census blocks in a tract are assumed to have the same education level distribution.

Table A-4. Distribution of Risk for People Living in Households below the National Median Income and Below the Poverty Line

Range of lifetime individual cancer risk (chance in one million)[a]	Numbers of people in different ranges for lifetime cancer risk[b]		
	Total population	People living in households below the national median income[c]	People living below the poverty line
Modeled risk from the Aerospace source category			
0 to 1	130,431,874	58,010,418	16,380,341
1 to 5	169,591	110,535	31,779
5 to 10	7,950	6,111	2,252
10 to 20	1,533	1,290	451
20 to 30	0	0	0
Total number	130,610,948	58,128,354	16,414,823
Average risk (chances in one million)	0.0116	0.0141	0.0141

Notes:

[a]Modeled risks are for a 70-year lifetime, based on the predicted outdoor concentration and not adjusted for exposure factors.

[b]Distributions by income and poverty status are based on modeled risk at the census block level, income data at the block group level, and poverty status at the census tract level. All census blocks in a block group or tract are assumed to have the same income distribution or poverty status, respectively.

[c]The median income is the national median household income in 2009, about $50,000.

Table A-5. Distribution of Risk for People Living in Linguistic Isolation

Range of lifetime individual cancer risk (chance in one million)[a]	Numbers of people in different ranges for lifetime cancer risk[b]	
	Total population	People living in linguistic isolation
Modeled risk from the Aerospace source category		
0 to 1	130,431,874	9,622,647
1 to 5	169,591	7,979
5 to 10	7,950	1,408
10 to 20	1,533	224
20 to 30	0	0
Total number	130,610,948	9,632,258
Average risk (chances in one million)	0.0116	0.0085

Notes:

[a]Modeled risks are for a 70-year lifetime, based on the predicted outdoor concentration and not adjusted for exposure factors.

[b]Distributions of linguistic isolation are based on modeled risk at the census block level, and linguistic isolation data at the block group level. All census blocks in a block group are assumed to have the same linguistic isolation population distributions.